APPLICATION FOR

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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that **Tetsurou Hamada**, residing in Japan; **Hitoshi Hara**, residing in Japan; **Yoshinori Kanda**, residing in Japan; **Hiroki Hasegawa**, residing in Japan, and **Toshihiro Hori**, residing in Japan, all citizens of Japan, have invented a new and useful **"COMBUSTION APPARATUS"** of which the following is a specification.

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COMBUSTION APPARATUS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a combustion apparatus for burning a liquid fuel.

DESCRIPTION OF RELATED ART

Some combustion apparatuses known in the art are of the type as disclosed in Patent Laying-Open Gazette No. 10-227453. A fuel spraying nozzle incorporated in this apparatus operates to blow a fuel mist to be burnt continuously. This nozzle is of the so-called return type that has an internal return path such that a portion of the fuel supplied from a fuel tank will flow back toward the tank through the internal return path and a return channel provided out of the nozzle.

Fig. 21 is a flow diagram showing the flow of fuel in the related art combustion apparatus that includes the return type nozzle. A fuel spraying nozzle 205 built in this apparatus 201 has a spray mouth for jetting a fuel mist. A fuel channel (or "a fuel canal") 209 connected to the nozzle 205 is composed of a feed channel (or "a feed canal") 210 reaching the spray mouth and a return channel (or "a return canal") 211 leading back therefrom to an upstream region of said channel. The feed channel 210 starting from a fuel tank 214 so as to terminate at an inlet of the spraying nozzle 205 does include electromagnetic valves 212 and 213 and an electromagnetic pump 215 that are arranged in series along the feed channel. On the other hand, the return channel 211 connected to a returning side of the nozzle 205 does include a check valve 216 and a proportional control valve 217, that are likewise arranged in series. A downstream end of the return channel 211

merges into the feed channel 210, at a junction intervening between the electromagnetic valve 212 and the electromagnetic pump 215.

The proportional control valve 217 disposed in the return channel 211 is the so-called "ball type" valve that cannot absolutely close this channel 211. Therefore, the one electromagnetic valve 212 is interposed between the junction and the fuel tank 214 so as to avoid any excessive or undesired flow of fuel from or towards this tank.

Fig. 22 shows the structure of proportional control valve 217 employed in the related art combustion apparatus 201. This valve has an internal fuel passage 221 formed in a shell 220 and extending between a fuel inlet end 222 and a fuel outlet end 223, with the inlet end 222 leading to the check valve 216. A valve seat 225 is formed at an intermediate point in the internal passage 221, and a spherical valve body 226 rests on this seat 225. A plunger 227 in contact with the valve body 226 is surrounded by an electromagnetic coil 228. With this coil being turned on with an electric current, it will make a stroke along the axis of shell so as to move the valve body 226 up and down.

As the plunger 227 displaces the valve body 226, the cross-sectional area of internal passage 221 will vary to change the flow rate of fuel advancing from the inlet end 222 to outlet end 223. A current regulator not shown but varying the intensity of electric power applied to the proportional control valve 217 will serve to control the fuel flow rate through the return channel.

The fuel stream effluent from the tank 214 will continuously be compressed in the electromagnetic pump 215, before entering the spraying nozzle 205.

The thus compressed fuel stream of a high pressure will reach the

spray mouth that is located at a distal end of the spraying nozzle 205, so that a noticeable portion of such a fuel stream is blown outwards to form a mist. The remainder of said fuel stream will flow back from this nozzle 205, through the check valve 216 and into the inlet end 222 of proportional control valve 217. The remainder having entered this valve 217 through its inlet end 222 is delivered to an upstream region of the feed channel, at a flow rate determined by the intensity of current being applied to said coil 228.

Gradual change or certain fluctuation in the temperature of the proportional control valve 217 has been observed in the related art combustion apparatus 201 during its operation. Such a change or fluctuation as being caused by the change in ambient temperature and/or the like will in turn change the temperature of coil 228 installed in the shell 220. Electric resistance of the coil 228 will vary in response to the change in its temperature, thereby rendering unstable the current intensity applied to the coil 228. Consequently, the flow rate at which the remainder of fuel stream flows back through the return channel will become unreliable. It has been somewhat difficult for the related art apparatus 201 to precisely regulate the spraying rate of fuel, failing to stabilize the condition of combustion state.

Thus, in order to solve such problem, the inventors performed experiments employing an injector valve 25 (an intermittently operating valve) shown in Figure 3 as a flow rate control valve of a fuel. The injector valve 25 employed in this case will intermittently open and close its valve by driving its valve body 33 within a very short period of time. More specifically, the injector valve 25 comprises an actuator 31, an electro-magnetic coil 32 and a valve body 33 in a shell (or a covering) 30. The

valve will open when the electromagnetic coil 32 is electrically energized to operate the actuator 31.

The injector valve 25 employed as a flow rate control valve allows to adjust an amount of heat generated per unit time more accurately compared with the case adopting a proportional control valve 216 or the like as a flow rate control valve. However, as a result of the experiment on this combustion apparatus employing the injector valve 25, it was revealed that a noise resulting from the opening and closing of the valve was generated. The noise is relatively small than the combustion noise resulting from the combustion operation to be hardly heard when the amount of heat generated in the combustion apparatus is large, whereas the noise resulting from the opening and closing of the injector valve 25 stands out when the amount of heat of the combustion apparatus is little. The noise generated by the collision of the valve body 33 and the shell 30 resulting from the opening and closing of the injector valve 25 is so jarring that it may make users or the like unpleasant.

SUMMARY OF THE INVENTION

An object of the present invention made in a view of the problems and drawbacks is therefore to provide an advanced combustion apparatus capable to accurately adjusting the sprayed rate of fuel with a small noise generated during its operation.

In order to achieve this object, a combustion apparatus provided herein has to comprise, as defined in the accompanying claim 1, a spraying means for spraying a fuel and a channel for flowing the fuel therethrough, an intermittently operating valve disposed in the channel so as to be closed and opened intermittently or periodically, wherein at least part of said valve is

enclosed with a casing.

Since the present combustion apparatus can now adjust the amount of heat accurately compared with a combustion apparatus adopting a proportional control valve or the like as a flow rate control valve. However, the intermittently operating valve may cause a metallic and jarring noise resulting from the opening and closing of the valve.

The present combustion apparatus has an intermittently operating valve, at least part of which is enclosed with a casing. Therefore, even if the frequency at which the valve must repeat open and close rises resulting from the combustion operation, the leakage of the noise resulting from the opening and closing of said valve can be greatly reduced. Preferably at least part of the casing is a sound insulating member.

As defined in the accompanying claim 2 dependent on claim 1, the casing comprises an inlet joint connected to an inlet side of the intermittently operating valve and an outlet joint connected to an outlet side of the intermittently operating valve.

In the present apparatus, since the casing comprises the inlet joint and the outlet joint, the mounting of the intermittently operating valve on the casing, the maintenance of the valve and the like can be readily performed.

The present apparatus employs a structure to enclose the intermittently operating valve with the inlet joint and the outlet joint. Because of such a structure it is preferable to make no space in the connecting portion between the inlet joint and the outlet joint so as to ensure to prevent the noise resulting from the opening and closing of said valve from leaking out.

Taking into account such a possible problem, and as defined in the accompanying claim 3 dependent on claim 1, the casing consists essentially of an inlet joint connected to an inlet side of the intermittently operating

valve and an outlet joint connected to an outlet side of the intermittently operating valve, both which joints are engaged mutually, and the intermittently operating valve being disposed in the space enclosed with the inlet joint and the outlet joint.

In the present apparatus, it is designed to engage the inlet joint and the outlet joint mutually with which the intermittently operating valve is enclosed. Therefore, a vibration resulting from the intermittently operating valve during a combustion operation will not cause a relative displacement between the joints.

Additionally, in this case, because of no relative displacement between the inlet joint and the outlet joint, a sealing condition of the space accommodating the intermittently operating valve shall not deteriorate. Therefore it may be possible to minimize the leakage of the vibration and the noise resulting from the intermittently operating valve during the combustion operation.

Further, taking into account such a possible problem similar to the invention as defined in the accompanying claim 3, and as defined in the accompanying claim 4 dependent on claim 1, the casing consists essentially of an inlet joint connected to an inlet side of the intermittently operating valve and an outlet joint connected to an outlet side of the intermittently operating valve, and the connecting portion with the inlet joint and the outlet joint being in close contact with each other.

As for the present apparatus, because the connecting portion of the inlet joint and the outlet joint is in close contact each other, of both of which the casing consists essentially, both joints shall not form a gap therebetween. Therefore, the noise resulting from the operation of the intermittently operating valve hardly leaks out of the casing.

As defined in the accompanying claim 5 dependent on claim 1, the casing consists essentially of an inlet joint connected to an inlet side of the intermittently operating valve and an outlet joint connected to an outlet side of the intermittently operating valve, the inlet joint and the outlet joint having an indentation (or recess) respectively, so that the indentations jointly form a through-hole for letting therethrough a wiring connected to the intermittently operating valve, and a seal which engages with each indentation so that it fits in the annular gap between the through-hole and a periphery of the wiring being mounted on the wiring.

In this case, engaging the seal with the through-hole formed by the indentations in the inlet joint and the outlet joint may allow to let readily therethrough the wiring connected to the intermittently operating valve. The present apparatus can also fit in the annular gap between the through-hole and the periphery of the wiring with the seal. In such a structure, it is possible to seal up the casing enclosed and to minimize the leaking of the noise resulting from the operation of the intermittently operating valve.

The present apparatus as defined in the accompanying claim 6 dependent on claim 1 further comprises a fuel pump for sending the fuel to the spraying means and disposed in the channel, and wherein the casing is directly connected to at least one of the fuel pump and the spraying means.

The present apparatus has a casing directly connected to at least one of the fuel pump and the spraying means. More specifically, at least one of an inlet joint and an outlet joint, both joints being components of the casing, is connected to at least one of the fuel pump and the spraying means. In other words, a piping, that connects the intermittently operating valve with the fuel pump and the spraying means, is to be secured to the inlet joint or the outlet joint. Therefore, in this case, it is possible to simplify the channel which

connects to the spraying means.

In the present apparatus, since the piping which connects the intermittently operating valve with the fuel pump and the spraying means is secured to the inlet joint or the outlet joint, it is easy to assemble the combustion apparatus. The present apparatus requires less numbers of its components than the combustion apparatus in the related art, and to reduce the manufacturing cost.

The present apparatus as defined in the accompanying claim 7 dependent on claim 1 further comprises a filling filled between the casing and the intermittently operating valve. Preferably the filling is elastic. The filling may be formed by injecting fluidized plastics into the space between the casing and the valve or be made up of elastic pellets stuffed into the space.

In this case it is possible to absorb the noise and the vibration generated resulting from the opening and closing of the intermittently operating valve in the filling. Consequently, the present combustion apparatus can operate combustion with hardly leaking out the metallic and jarring noise resulting from the opening and closing of the intermittently operating valve and without making users or the like unpleasant.

A combustion apparatus as defined in the accompanying claim 8 comprises a spraying means for spraying a fuel, a channel for flowing the fuel therethrough, an intermittently operating valve disposed in the channel so as to be closed and opened intermittently or periodically, a casing enclosing at least part of the intermittently operating valve, and at least one fluidic component disposed in the channel and secured to the casing. In this specification, a fluidic component includes a valve, a nozzle, a filter, a joint for piping, a measuring instrument such as a flow meter, a pressure meter and

a temperature meter, and so on.

As for the present apparatus, at least one fluidic component disposed in the channel is secured to the casing enclosing at least part of the intermittently operating valve. That is, in the present apparatus, the intermittently operating valve or other fluidic component is secured to the casing to form a unit, so that this unit allows to constitute the channel. Therefore, the present invention permits to simplify the structure of the channel for the combustion apparatus. Further because of the simple channel in the present apparatus, it is possible to reduce the labor and the manufacturing cost which are required for the assembling work.

Still further, the present apparatus is provided with the intermittently operating valve in the channel so as to adjust accurately the flow rate of the fuel flowing in the channel regardless of change in ambient temperature or the like. Therefore, in this case, it can stabilize the condition of spraying the fuel and of combustion so as to serve to accurately control the amount of heat.

The intermittently operating valve can adjust accurately the fuel flow rate compared with a flow rate control valve such as a proportional control valve, though it may generate the metallic and jarring noise if the frequency of the opening and closing thereof rises. As mentioned above, in the present apparatus, at least part of the intermittently operating valve is enclosed with the casing, by which the noise resulting from the opening and closing of said valve is insulated, so as to, consequently, be able to minimize the leakage of the noise resulting from the operation of said valve.

The present combustion apparatus as defined in the accompanying claim 9 dependent on claim 8 comprises a pressure buffer for buffering a pressure in the channel disposed in the channel and secured to the casing.

The present apparatus has the structure which secures the casing enclosing the intermittently operating valve to the pressure buffer so that there is no need to separately dispose a piping to connect the pressure buffer to said valve. Consequently, in this case, it is possible to prevent the noise resulting from the operation of said valve from leaking out, as well as simplify the channel.

The present apparatus as defined in the accompanying claim 10 dependent on claim 8 further comprises a checking means disposed in the channel and secured to the casing for preventing the fuel flowing in the channel from flowing backward.

The present apparatus has the structure which secures to the casing the checking means so that there is no need to dispose a piping to connect the intermittently operating valve to the checking means. Thus, the present apparatus, compared with some combustion apparatuses in the related art, will have its channel to be simple, the structure of the combustion apparatus to be compact, and as well as the assembly process thereof to be simplified.

The present apparatus as defined in the accompanying claim 11 dependent on claim 8 further comprises a pressure buffer for buffering the pressure in the channel, and a checking means disposed in the channel. The pressure buffer and the checking means are secured to the casing.

The present apparatus has the structure in which the pressure buffer and the checking means are secured to the casing, so that it is possible to simplify the channel more. Therefore, this invention allows the channel of the combustion apparatus to be a compact structure further more, as well as the assembling process of the combustion apparatus to be simplified.

As defined in the accompanying claim 12 dependent claim 8, at least part of the channel for flowing the fuel therethrough is secured to the casing.

In such a structure, the channel may be constructed simply and easily so as to minimize the manufacturing time and cost, which are required to assemble the combustion apparatus.

A combustion apparatus as defined in the accompanying claim 13 comprises a spraying means for spraying a fuel, a channel for flowing the fuel therethrough, an intermittently operating valve disposed in the channel so as to be closed and opened intermittently or periodically, a casing enclosing at least part of the intermittently operating valve, and at least one elastic member interposed between said valve and the casing.

In the present apparatus the intermittently operating valve is disposed in the channel, so that even if the ambient temperature or the like changes the sprayed amount of the fuel can be adjusted in good accuracy. Further, since the present apparatus has the structure in which at least part of said valve is enclosed with the casing, the noise resulting from the opening and closing of said valve hardly leaks out even if the frequency of its operation of said valve rises during the combustion operation.

The present apparatus, wherein the elastic member is interposed between the intermittently operating valve and the casing, can absorb in the elastic member most of the noise and the vibration resulting from the opening and closing of said valve during the combustion operation. Thus, in such a structure, the noise resulting from the operation of the intermittently operating valve will be reduced to the extent of being hardly heard because the noise is relatively small than the combustion noise resulting from the combustion operation. Further, such a structure can ensure to prevent the vibration generated at the intermittently operating valve from transmitting to the piping connected to the casing .

Still further, the present apparatus can regulate the position where the

intermittently operating valve is mounted in good accuracy with the elastic member disposed in the space between the intermittently operating valve and either of the inlet and outlet joints. Therefore, in this case, said valve may not chatter during the combustion operation, consequently the noise by chattering of said valve is not generated either.

As defined in the accompanying claim 14 dependent on claim 13, the intermittently operating valve comprises a valve body capable of being driven so as to close and open the valve periodically and a valve body housing for accommodating the valve body, and the elastic member being mounted on the valve body housing.

Since the valve body housing is a region that accommodates the valve body that is driven to close and open the valve periodically, the largest vibration and noise are generated there during the operation of the intermittently operating valve. The present apparatus involves the elastic member mounted on the valve body housing that is assumed to generate the largest vibration and noise therein. Therefore, the present apparatus can absorb in the elastic member most of the vibration and the noise resulting from the operation of said valve.

As defined in the accompanying claim 15 dependent on claim 13, the intermittently operating valve is connected to the casing via at least two connecting portions at both ends on inlet and outlet sides of the valve, and at least the connecting portion at the end of the outlet side is sealed up with and supported firmly by the elastic member.

In the present apparatus, the intermittently operating valve is connected to an inlet joint and an outlet joint, and at least the connecting portion at the outlet joint is sealed up and supported firmly by the elastic member so that it may not cause the leakage of the fuel at said connecting portion. In addition,

in this case, it is possible to minimize the transmission of the vibration of the intermittently operating valve and also restrain the leakage of the vibration and the noise resulting from the operation of the intermittently operating valve.

Further, in the present apparatus, because of a structure wherein at least part of the intermittently operating valve is enclosed with a sound insulation member, the noise resulting from the operation of said valve hardly leaks outside.

As mentioned above, the present apparatus has a structure which absorbs the vibration and the noise generated at the intermittently operating valve in both the elastic member and the casing, so that it achieves double methods for preventing the noise from leaking out. Thus, the present apparatus can operate combustion with the jarring noise resulting from the operation of said valve hardly leaking out and without making users unpleasant. Preferably at least part of the casing is a sound insulation member.

As defined in the accompanying claim 16 dependent on claim 13, the at least one elastic member comprises two elastic members, one of which is interposed between the casing and an inlet side of the valve and the other of which is interposed between the casing and an outlet side of the valve, and the elastic member interposed between the casing and the outlet side has a stronger elastic force than the elastic member interposed between the casing and the inlet side

As mentioned above, the present apparatus comprises the intermittently operating valve so as to be closed and opened periodically and the opening and closing of the valve is operated at the outlet side. Therefore, the intermittently operating valve generates bigger vibration at the outlet side

than the inlet side.

In the present apparatus, the outlet side elastic member mounted on the outlet side where a bigger noise is assumed to be generated has a stronger elastic force than the inlet side elastic member mounted on the inlet side. Thus, in this case, most of the vibration resulting from the operation of the intermittently operating valve can be surely absorbed further more, as well as the noise can be prevented from leaking.

As defined in the accompanying claim 17 dependent on claim 13, the intermittently operating valve comprises a built-in actuator reciprocating periodically so as to open and close the valve, and the elastic member is interposed in the space between the casing and the valve where a force in the direction of the reciprocation of the actuator acts.

The intermittently operating valve employed in this case has a built-in actuator reciprocating in the predetermined direction so as to drive the valve body to open and close the valve by synchronizing with the reciprocation of this actuator. Thus, the valve generates a big vibration in the direction of the reciprocation of the actuator during the operation. In the present apparatus, the elastic member is interposed in the space where a force in the direction of the reciprocation of the actuator, which comprises said inlet joint or said outlet joint and the intermittently operating valve, acts, so as to absorb in the elastic member most of the vibration generated resulting from the reciprocation of the actuator.

Still further, in the present apparatus, at least part of the intermittently operating valve is enclosed with the casing, so that most of the noise resulting from the operation of the valve is insulated by said casing and thus may not leak out.

The present apparatus, as mentioned above, has a structure by which

the noise is absorbed in or insulated by both the elastic member and the casing, so as to achieve double methods for preventing the noise from leaking out. Therefore, in this case, the noise resulting from the opening and closing of the intermittently operating valve can be surely prevented from leaking out.

As defined in the accompanying claim 18 dependent on claim 13, the intermittently operating valve has a built-in actuator reciprocating periodically so as to open and close the valve, and the present apparatus further comprises a vibration-isolating member interposed between the valve and the casing and for buffering a force acting from the valve to the casing in the direction of the reciprocation of the actuator, and a seal interposed between the valve and the casing so as to prevent the fuel flowing in and out of the valve from leaking.

Since the present apparatus comprises the vibration-isolating member for buffering a force acting on the casing in the direction of the reciprocation of the actuator, the vibration generated at the intermittently operating valve is hardly transmitted to the casing and other members connected to the casing. Therefore, the present apparatus may not adversely affect on the state of combustion by the generation of the noise and the transmission of the vibration during the combustion operation.

Further, the present apparatus comprises the seal so as to prevent the fuel flowing in and out of the intermittently operating valve from leaking out. Consequently, the present invention may provide a combustion apparatus in which the noise and the vibration resulting from the operation of the intermittently operating valve are not generated, nor the leakage of the fuel.

The present apparatus as defined in the accompanying claim 18 mentioned above involves the vibration-isolating member and the seal. The

vibration-isolating member and the seal may be made of elastic material. Herein the vibration-isolating member, for buffering an impact, is preferable to have strong elastic force, on the other hand as for the seal, the sealing characteristics may be rather damaged if the seal has too strong elastic force.

Therefore, taking into account such a possible problem, and as defined in the accompanying claim 19 dependent on claim 13, the intermittently operating valve has a built-in actuator reciprocating periodically so as to open and close the valve, and the present apparatus further comprises a vibration-isolating member interposed between the valve and the casing and for buffering a force acting from the valve to the casing in the direction of the reciprocation of the actuator, and a seal interposed between the valve and the casing so as to prevent the fuel flowing in and out of the valve from leaking out. The vibration-isolating member has a stronger elastic force than the seal.

The vibration-isolating member employed in the present apparatus has a stronger elastic force than the seal so as to firmly accept the vibration resulting from the operating of the intermittently operating valve. On the other hand, the seal has a smaller elastic force than the vibration-isolating member so as to surely prevent the fuel from leaking. Consequently, the present invention can provide a combustion apparatus capable of not only controlling the transmission of the vibration generated at the intermittently operating valve and the noise thereby but also preventing the fuel from leaking.

As defined in the accompanying claim 20 dependent on claim 19, the intermittently operating valve has a built-in actuator reciprocating periodically so as to open and close the valve, and the elastic member is interposed between the valve and the casing and comprises a vibration-

isolating portion for buffering a force acting from the valve to the casing in the direction of the reciprocation of the actuator and a sealing portion for preventing the fuel flowing in and out of the valve from leaking and interposed between the valve and the casing.

The elastic member provided in the present apparatus involves the vibration-isolating portion and the sealing portion so as to surely prevent not only the vibration and the noise resulting from the operation of the intermittently operating valve but also the leakage of the fuel.

BRIEF DESCTIPTION OF THE DRAWINGS

Figure 1 is a schematic front elevation of a combustion apparatus provided in an embodiment of the present invention;

Figure 2 is a diagram showing a fuel pipe line that is constructed in the apparatus shown in Figure 1;

Figure 3 is a cross section of an injector valve incorporated in the apparatus of Figure 1;

Figure 4 is a perspective view showing the connection of the injector valve shown in Figure 3 to the casing;

Figure 5 is a cross section of the casing shown in Figure 4 as seen from direction of A;

Figure 6 is a cross section showing the connection of the casing accommodating the injector valve shown in Figure 3 to an electromagnetic pump;

Figure 7 is a cross section showing an modified embodiment of the casing shown in Figure 4;

Figure 8 is a perspective view showing a modified embodiment of the elastic member mounted on the injector valve shown in Figure 3;

Figure 9 is a cross section showing another embodiment of the casing shown in Figure 4;

Figure 10 is a cross section showing still another embodiment of the casing shown in Figure 4;

Figures 11A and 11B are perspective views jointly showing yet another embodiment of the casing shown in Figure 4;

Figure 12 is a perspective view showing the connection of the injector valve to the inlet joint and the outlet joint of the casing which is the further embodiment of the casing shown in Figure 4;

Figure 13 is a perspective view of the inlet joint shown in Figure 12 as seen from the bottom;

Figure 14 is a cross-sectional perspective view of the outlet joint shown in Figure 12;

Figure 15 is a cross section showing the injector valve shown in Figure 3 as accommodated in the casing shown in Figure 12;

Figures 16A and 16B are perspective views jointly showing a modified embodiment of the casing shown in Figure 12;

Figure 17 is a cross section of the injector valve as accommodated in the casing shown in Figure 12 employing the elastic member shown in Figure 8;

Figure 18 is a perspective view of another modified embodiment of the casing shown in Figure 12;

Figure 19 is a cross section of the injector valve as accommodated in the casing shown in Figure 18;

Figure 20 is a schematic front view of a still further embodiment of the present invention;

Figure 21 is a schematic view of a fuel pipe line in the related art combustion apparatus; and

Figure 22 is a cross section of a proportional control valve employed in the related art combustion apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 1, a combustion apparatus of a first embodiment is generally denoted at the reference numeral 2. This apparatus 2 comprises a nozzle block 8 having an end opened in a hollow shell 7, and a combustion chamber 10 is attached to the end of nozzle block 8. A fan or blower 11 mounted on the shell 7 will operate to feed the ambient air into the combustion chamber 10. A fuel spraying nozzle (as the spraying means) 12 is installed in the nozzle block 8 in order to spray a fuel towards and into the combustion chamber 10.

The spraying nozzle 12 has a spray mouth (not shown) for jetting the fuel. An internal feed path (not shown) and an internal return path (not shown) leading to or starting back from the spray mouth are formed in or for the nozzle 12. Thus, the fuel spraying nozzle 12 will operate to jet a portion of the fuel that is being fed from the outside through the feed canal. The remainder of said fuel will be left unsprayed to subsequently flow back through the return canal.

As seen in Fig. 2, a fuel pipe line 13 connects the fuel spraying nozzle 12 to a fuel tank 15 holding therein a mass of the fuel. The pipe line 13 consists mainly of a fuel feed canal (i.e., a feed channel) 16 and a return canal (i.e., a return channel) 17, such that the former canal communicates with an internal feed path formed in the nozzle 12 and the latter canal 17 communicates with an internal return path also formed in the spraying nozzle 12. As shown in Fig. 1, pipes 5 forming those feed and return canals 16 and 17 extend outwardly of the shell 7 so as to lead to an injector

valve 25 and an electromagnetic pump 18, that are detailed below. Those pipes 5 also connected to the nozzle 12 are each bent several times at substantially right angles between the nozzle and the valve 25 or pump 18. Bends formed thus in said pipes will make same more tenacious on one hand, and will attenuate any vibration being transmitted from said pump 18 or injector valve 25 on the other hand. Thus, such a vibration will scarcely reach the spraying nozzle 12, thereby protecting it from damage.

The feed canal 16 combining the nozzle 12 with the fuel tank 15 in series does serve to supply the nozzle with the fuel stored in the tank. Disposed in this canal 16 are the electromagnetic pump 18, an electro-magnetic valve 20 and a check valve (as a feed channel checking means) 21. The check valve 21 normally stands closed, and an activation pressure (that is a minimum actuating pressure) for opening this valve is higher than a maximum hydrostatic head of the fuel in tank 15 standing in fluid communication with the feed canal 16. In other words, the hydrostatic pressure caused by the fuel stored in the tank 15 will never exceed the minimum pressure for activating the checking valve 21 to open. For example, in the combustion apparatus 2 of the present embodiment, the fuel tank 15 is disposed higher than the valve 21 by 0.5 meter. The minimum actuating pressure is 0.2 Kgf/cm^2 (viz., 2.0×10^4Pa) for this valve 21, that is much higher than the hydrostatic head 0.04 Kgf/cm^2 (viz., 0.39×10^4Pa) for the fuel in tank 15. Thus, the fuel will not flow towards the spraying nozzle 12 unless the pump 18 compresses it. Although the minimum actuating pressure for said valve 21 is selected herein to be high by about 5 times of said hydrostatic head of said fuel, the ratio of the former to the latter may fall within a range from 3 to 5.

The fuel tank 15 may alternatively be positioned at any height, from

1.5 *m* above to 2.0 *m* below the valve 21, thus making the hydrostatic head not higher than 0.12 Kgf/cm^2 (viz., $1.2 \times 10^4 Pa$).

As noted above, the normally closed check valve 21 shall not naturally open merely due to hydrostatic head of the fuel in tank 15. There may be a possibility that the electromagnetic valve 20 would unintentionally open, though fuel feed to the nozzle 12 had to be interrupted for the combustion apparatus 2 then standing inoperative. Even in such an accident, the check valve 21 will surely stop the fuel not to leak out towards a downstream canal region. If and when the fuel from the tank 15 has to be sprayed, it will be compressed by the pump 18 and enabled to pass through the valve 21 and flow to the nozzle 12.

A portion of the fuel fed to the nozzle 12 will be left there unburnt, and such a remainder will flow back towards the tank 15 through the return canal 17. A downstream end (near the tank 15) of the return canal 17 merges into the feed canal 16 at its intermediate point located on the upstream side of electromagnetic pump 18 (and facing the tank 15). Disposed at another intermediate point of the return canal 17 is a temperature sensor (viz., temperature sensing means) 22 for detecting the temperature of fuel flowing back through this canal. A further check valve (as the return channel checking means) 23 is disposed downstreamly of the sensor 22 so that the fuel can flow towards the tank 15 but is inhibited from flowing in a reversed direction away from this tank. Disposed on the downstream side of the check valve 23 is the injector valve (viz., intermittently operating valve) 25 that will be opened and closed periodically at given time intervals. An accumulator 26 intervening between the injector valve 25 and the further check valve 23 will serve to buffer fluctuation in pressure of the fuel flowing through the return canal

17.

The injector valve 25 will operate at an extreme high frequency to be opened and then instantly closed. As shown in Fig. 3, this valve25 comprises a shell 30, an actuator 31 held therein, an electromagnetic coil 32 for driving the actuator 31, and a valve body 33 movable in unison with the actuator 31. Formed at opposite ends of the shell 30 are a fuel inlet 35 and a fuel outlet 36, with an internal fuel passage 37 extending between them 35 and 36 and through the shell 30.

The shell 30 covers the greater part of the injector valve 25 from the end having the fuel inlet 35 (hereinafter called as "an inlet end") to the proximity of the fuel outlet 36. That is, part of the injector valve 25 except the end having the fuel outlet 36 (hereinafter called as "an outlet end") is covered with the shell 30. A part of a metallic valve body housing 39, in which the valve body 33 is accommodated, is exposed at the end of the fuel outlet 36 of the injector valve 25.

The shell 30 has a connecting terminal 38 leading to the electromagnetic coil 32 so that power supply through this terminal 38 will activate said coil 32. Consequently, the actuator 31 will be energized within the shell 30, thereby simultaneously driving the valve body 33 to open the passage 37 that is a part of the return canal 17. The valve body 33 of the present embodiment thus opens the passage 37 instantly in response to the coil 32 energized with an electric current, and said body 33 will close the passage instantly upon inactivation of said coil 32. The injector valve 25 in such a closed state in response to inactivated coil 32 will have its valve body 33 very tightly shutting the fuel passage 37 to absolutely close the return canal 17.

Circular grooves 40 and 41, with which O-rings 43 and 45(elastic

members) engage respectively, are formed respectively at the inlet end of the shell 30 and at the outlet end of the valve body housing 39. The O-rings 43 and 45 are fitting in the annular gap between the injector valve 25 and an inlet joint 46 and an outlet joint 47, both which are detailed below, as well as of functioning as the vibration-isolating member for preventing the vibration of the injector valve 25 from transmitting to the inlet joint 46, the outlet joint 47 and the like.

The O-ring 45, which is interposed between an outlet side of the injector valve 25 and the outlet joint 47, is especially thicker and has a stronger elastic force than the other O-ring 43. The O-ring 45 is set in the space formed in the direction of the reciprocation of the actuator 31 between the injector valve 25 and the outlet joint 47, that is, at the space where a force in the direction of the reciprocation of the injector valve 25 acts. As a result the O-ring 45 can ensure to absorb the vibration generated in the direction of the reciprocation of the injector valve 25, and can prevent the noise from leaking out.

The injector valve 25 is accommodated in a casing 50 which consists essentially of the inlet joint (an upper case) 46 and the outlet joint (a lower case) 47 as shown in Figure 4 and Figure 5. Further in detail, the upper case 46 is connected to the inlet 35 of the injector valve 25, whereas the lower case 47 is connected to the outlet 36 thereof.

The upper case 46 is made of a die cast zinc alloy and substantially of box shape as shown in Figure 4. Said case 46, as shown in Figure 4 and Figure 5 is accompanied by a piping connector 56 to be connected to the fuel system and a check valve housing 54 for accommodating a check valve 21 on the top surface 55a of the case 46. An accumulator 20 is secured to the side surface 55b of the case 40. The case 46 has an inlet connecting space 51

that can receive the inlet 35 of the injector valve 25 and a housing 52 for accommodating the terminal 38 of the injector valve 25.

The piping connector 56 comprises a connecting portion 56a where a piping is connected, an engaging portion 56b which is a substantially hexagon in a plan view, and a flange portion 56c. The connector 56 has a through-hole 56d which is passed through in the axial direction of the connecting portion 56a. Said connector 56 is attached to a check valve housing 54 mentioned below by means of a fixing plate 57. Further specifically, the fixing plate 57 is a plate body 57a with a hexagonal engaging hole 57b and a pair of insertion holes 57c. The plate body 57a is of a shape substantially in conformity with a shape of the connector 56 in a plan view. The engaging hole 57b is substantially in conformity with a shape of the engaging portion 56b of the piping connector 56. The insertion holes 57c are for inserting screws. By inserting the engaging portion 56b in the engaging hole 57b of the fixing plate 57 and screwing the fixing plate 57 to the check valve housing 54 to interpose the flange portion 56c, the piping connector 56 is secured.

The checking valve housing 54 has a pair of screw holes 54a to screw the fixing plate 57, a through-hole 54b passing through in the vertical direction at a substantial center. The through-hole 54b communicates with the through-hole 56b of the connector 56. The check valve 18 is disposed in the through-hole 54b for flowing the fuel flowed in from the connector 56 towards the injector valve 25.

The inlet connecting space 51 comprises an inlet portion 48 for flowing therethrough the fuel supplied from outside and a receptacle 53 continuing to the inlet portion 48 and being substantially of same diameter with the inlet end of the injector valve 25. The through-hole 54b of the check valve

housing 54 disposed on the top surface 55a of the upper case 46 communicates with the inlet portion 48, where a communicating hole 49 communicating with the accumulator 20 attached to a side surface 55b of the upper case 46 is also disposed. The receptacle 53 is a concave part of the shape that is substantially in conformity with the inlet 35 of the injector valve 25.

The housing 52 is formed at the position adjacent to the inlet connecting space 51 of the upper case 46 and is a concave part opened at the bottom 55c of the upper case 46. An indentation 58a, which forms a part of opening 58 for letting therethrough out a wiring 38a connected to the terminal 38, is formed at the bottom 55c of the side wall 55d of the housing 52.

A surface exposed at the bottom 55c and at the side 55b in the upper case 46 is a part of a connecting surface 55e with the lower case 47. On the other hand, the side exposed at the top 60 and at the side 59a in the lower case 47 is a part of a connecting surface 59b with the upper case 46. The connecting surfaces 55e and 59b are both made smooth by the milling. Therefore superposing the upper case 46 and the lower case 47 makes no gap between the connection surfaces 55e and 59b. As a result, a casing 50 is sealed up and it prevents the noise generated by the vibration of the injector valve 25 from leaking outside thereof.

The lower case 47 is made of a die cast zinc alloy and is a member for accommodating the portions of the outlet 36 of the injector valve 25. Said case 47 has an opening at the top 60 and its shape is substantially in conformity with the bottom 55c of the upper case 46, as shown in Figure 4 and Figure 5. The lower case 47 consists essentially of a body receptacle portion 61 engaging with the shell 30 and the valve body housing 39 of the injector valve 25, and a protrusion portion 62.

The body receptacle portion 61 is a concave part extending from a top surface 60 to a foot 63 of the lower case 47, and disposed at the position which corresponds to the inlet connecting space 51 of said case 47. Further, at the bottom of the body receptacle portion 61, a receptacle 42 is formed for an end of the valve body housing 39 to be inserted therein. Thus, when inserting the injector valve 25 in the body receptacle portion 61, the body receptacle portion 61 is engaged with the valve body housing 39 through the O-ring 45, an end of said housing 39 is fixed to the receptacle 42 as shown in Figure 5. Connecting portions 67 and 68 communicating with the receptacle 42 of the body receptacle portion 61 are disposed at the position corresponding to lower part of the body receptacle portion 61 and at sides 65 and 66 of the lower case 47. A pump 15 is connected to the connecting portion 67 as shown in Figure 6. On the other hand, the connecting portion 68 is connected between the tank 15 and the pump 18 so as to flow out the fuel jetted from the injector valve 25.

The protrusion portion 62 is disposed at the position adjacent to the body receptacle portion 61 in the lower case 47, and opposite to the housing 52 when the upper case 46 is superposed thereon. Since the top surface 60 of the protrusion portion 62 is opened, the space for accommodating the terminal 38 of the injector valve 25 is formed between the housing 52 and the protrusion portion 62 when the lower case 47 is covered with the upper case 46. Further, an indentation 58b, which forms a part of an opening 58 for letting therethrough out the wiring 38a connected to the terminal 38, is formed on the top 60 of the side 59a of the protrusion part 62.

The upper case 46 is superposed so that the bottom 55c of the upper case 46 may cover the top 60 of the lower case 47 from above as shown in Figure 4, so as to form a housing 70 for accommodating the injector valve 25

and a terminal housing 71 for accommodating the terminal 38 which protrudes from the shell 30 of the injector valve 25. The injector valve 25 is accommodated in the housing 70 so that the inlet 35 faces to the upper case 46 and also the outlet 36 faces to the lower case 47. Further, the terminal 38 of the injector valve 25 is accommodated in the terminal housing 71.

Around the wiring 38a connected to the terminal 38 of the injector valve 25, a grommet 72 for sealing the periphery of the wiring 38a is mounted. The grommet 72 is made of rubber and comprises an engaging portion 72a of substantially the same diameter as the opening 58 and a large diameter portion 72b of a diameter larger than the diameter of the opening 58 as shown in Figure 7. The wiring 38a connected to the terminal 38 is let therethrough out from the opening58, and the annular gap between the opening 58 and the wiring 38a is fitted by engaging the engaging part 72a of the grommet 72 with the indentations 58a and 58b.

The inlet end of the injector valve 25 is inserted in a receptacle 53 of the upper case 46 as shown in Figure 5 and Figure 6. The space between the injector valve 25 and the receptacle 53 is sealed by the O-ring 43 set in the groove 40 of the injector valve 25. In such a structure, it prevents the fuel from leaking from the space between the injector valve 25 and the receptacle 53, and the vibration of the injector valve 25 hardly transmits to the upper case 46.

The outlet end of the injector valve 25 is inserted in a receptacle 42 of the body receptacle portion 61 of the lower case 47. The space between the injector valve 25 and the receptacle 42 is sealed by the O-ring 45 set in the groove 41 formed adjacent to the outlet 36 of the injector valve 25. In such a structure, it makes possible to prevent the fuel from leaking from the space between the valve body housing 39 of the injector valve 25 and the body

receptacle portion 61. Further, the O-ring 45 is made of rubber so as to have an elasticity. Therefore, it allows to absorb vibration and impact in the axial direction of the injector valve 25 resulting from the reciprocation of the actuator 31. Still further, the O-ring 45 is made of a different material from that of the valve body housing 39 and the natural frequency of the vibration thereof are so different that the vibration generated in the valve body housing 39 is not amplified.

On the other hand, the valve body housing 39 around which the O-ring 45 is set is not covered with the shell 30, and may result in easily leaking the vibration and the noise outside. Additionally, the valve body housing 39 is a part where the vibration and the noise may be generated easily resulting from the opening and closing of the valve since the valve body housing 39 accommodates the valve body 33 therein. However, in this preferred embodiment, the O-ring 45 is interposed between the injector valve 25 and the body receptacle portion 61, so that the vibration resulting from the operation of the injector valve 25 is absorbed in the O-ring and hardly transmits to the upper case 46. Therefore, in the combustion apparatus 2 in this preferred embodiment, the metallic noise resulting from the operation of injector valve 25 hardly leaks outside.

In the combustion apparatus 1 in this preferred embodiment, the injector valve 25 is constituted in such a manner that the both ends thereof are supported by the upper case 46 and the lower case 47 by the O-rings 43 and 45. Therefore, it is possible to prevent surely the vibration that results from the operation of the injector valve 25 from transmitting, as well as to minimize a radial vibration of the injector valve 25.

In the preferred embodiment mentioned above, it may be also possible to fill such as a filling made of silicone in the annular gap between the lower

case 47 and the injector valve 25. In such a structure to fill a filling made of an elastic material such as silicone, it may absorb in the filling the impact and the vibration resulting from the opening and closing of the injector valve 25. Thus, such a structure to fill the filling member in the annular gap or the like may permit to absorb the noise and the vibration resulting from the operation of the injector valve 25 more efficiently and to prevent the leakage outside.

Such a structure by which the circular O-rings 43 and 45 are mounted on the injector valve 25 as the elastic member for buffering the vibration and the noise generated in the valve is illustrated in the preferred embodiment, though this invention is not limited to that. More specifically, an O-ring 75 may be mounted around the valve body housing 39 of the injector valve in addition to the O-rings 43 and 45 as shown in Figure 7. In this case the O-ring 75 is interposed between the wall of receptacle 42 disposed at the bottom of the body receptacle portion 61 and the valve body housing 39 of the injector valve 25.

When connecting the injector valve 25 to the lower case 47 by using the O-ring 75, as shown in Figure 7, the annular gap between the wall of receptacle 42 and the valve body housing 39 of the injector valve 25 is fitted in by not only the O-ring 45 but also the O-ring 75. Therefore, in this case, it surely minimizes the radial vibration of the injector valve 25, as well as it reduces further more the transmission of the vibration of the injector valve 25.

Still further, the elastic member mounted around the injector valve 25 can be a buffer 73, as shown in Figure 8, which is made of rubber and comprises a main body 73a of cylindrical shape in conformity with the valve body housing 39 and a flange 73b connected unitarily to one end of the main body 73a. As shown in Figure 9, when the injector valve 25 is connected to

the lower case 47 by using the buffer 73, the main body 73a is interposed between the wall of receptacle 42 formed at the bottom of the body receptacle portion 61 and the valve body housing 39 of the injector valve 25 whereas the flange 73b is interposed between the shell 30 and the bottom of the body receptacle portion 61.

When connecting the injector valve 25 to the lower case 47 by using the buffer 73, the annular gap between the wall of receptacle 42 and the valve body housing 39 of the injector valve 25 is fitted with the main body 73a as shown in Figure 9, so that it may minimize the radial vibration of the injector valve 25, as well as it reduces further more the transmission of the vibration of the injector valve 25.

Further, the flange 73b of the buffer 73 may fit in the annular gap formed between the injector valve 25 and the lower case47 in the direction of the reciprocation of the actuator 31. Therefore, the flange 73b may absorb the vibration in the axial direction of the injector valve 25 resulting from the reciprocation of the actuator 31.

As mentioned above, the injector valve 25 installs the actuator 31 reciprocating in a constant direction so as to drive the valve body 33 to open and close the valve. Therefore, a force intending to start moving in the direction of the operation of the actuator 31 acts on the injector valve 25 during the operation of the combustion apparatus 2. Therefore, if there is a space extending in the direction of the operation of the actuator 31 between the injector valve 25 and the casing 50, it may cause shaking of the injector valve 25 in the casing 50. If the injector valve 25 shakes, it may cause transmitting the vibration thereof to the casing 50 and generating the noise. Further, if the injector valve 25 shakes, the O-rings 43 and 45 (i.e., seals) interposed between the injector valve 25 and the casing 50 for preventing the

leakage of the fuel may be worn out.

In a view of the problems and the drawbacks, therefore, it is preferable to be such a structure as interposing an O-ring 44 (vibration-isolating member) between the inlet end of the injector valve 25 and the inlet portion 48 of the casing 50 for example as shown in Figure 10. The O-ring 44 may have an effect to buffer the force acting in the direction of the operation of the actuator 31 built in the injector valve 25 and to restrain shaking of the injector valve 25. That is, interposing the O-ring 44 in addition to the O-ring 43 between the injector valve 25 and the casing 50 allows to distribute the vibration generated vertically and horizontally in Figure 10 resulting from the operation of the injector valve 25 to the O-rings 43 and 44, and to restrain the transmission of the vibration and the noise thereby. Interposing the O-ring 44 so as to prevent the injector valve 25 from shaking may also control a wear-out of the O-rings 43 and 45 and prevent surely the fuel from leaking.

As for the casing 50 employed in the combustion apparatus 2 in the preferred embodiment, both the connecting surface 55e of the upper case 46 and the connecting surface 59b of the lower case 47 are smooth. Thus, a gap is not formed therebetween so that the noise resulting from the operation of the injector valve 25 hardly leaks out. However, relative displacement between of the cases 46 and 47 caused by some reasons such as screws fixing the upper case 46 to the lower case 47 loosen may form a little gap therebetween. Thus the gap may be formed, resulting in leakage of the noise generated at the injector valve 25 from this gap.

Therefore, taking into account such a possible problem, the casing 50 can be constituted for example as shown in Figures 11A and 11B. More specifically, it can be constituted in such a manner to form a rectangular protrusion 76 on along an inner periphery of the side 55d on the bottom 55c

of the upper case 46 of the casing 50 as shown in Figure 11A, and as well as to form an engaging step 77 capable of engaging with the protrusion 76 along an inner periphery of the side 59 of the lower case as shown in Figure 11B. Thus, when engaging the upper case 46 with the lower case 47, the protrusion 76 engages with the engaging step 77. Therefore, for example, even if such as the screws for fixing the upper case 46 to the lower case 47 loosen, thanks to no relative displacement between the upper case 46 and the lower case 47 by such an engaging structure of the protrusion 76 and the engaging step 77, a gap therebetween is not formed. Thus, in this structure of the casing 50 as shown in Figures 11A and 11B, it may surely prevent the gap from being formed by the transmission of the vibration generated at the injector valve 25 and the noise from leaking.

The combustion apparatus 2 in the preferred embodiment mentioned above is of the type as accommodating the injector valve 25 in the casing 50 as shown in Figures 5, 7, 9, and the like, though this invention is not limited to this. It can be of the type, for example, as accommodating the injector valve 25 in a casing 80, as described hereafter in detail referring to the drawing for the structure. In the description below, the same reference numerals are put to common parts with the preferred embodiment mentioned above and the description in details is omitted.

The injector valve 25 is enclosed with a casing 80 which consists essentially of an inlet joint 81 and an outlet joint 82 as shown in Figure 12, 13 and 14. The casing 80 is composed of the upper case 81(inlet joint) and the lower case 82(outlet joint). More specifically, the upper case 81 is connected to the inlet 35 of the injector valve 25, and the lower case 82 is connected to the outlet 36 thereof. The injector valve 25 is accommodated in the inner space formed between the upper case 81 and the lower case 82.

The upper case 81 is made of metal and a substantially box shape member as shown in Figures 12 and 14. The upper case 81 is mainly constituted by an inlet connecting portion 86 engaged with the inlet 35 of the injector valve 25 and a housing 87 for accommodating a terminal 38 of the injector valve 25.

The inlet connecting portion 86 forms a receptacle 88 of substantially the same diameter as the outer diameter of the inlet 35 of the injector valve 25 at the bottom 85 of the inlet joint 81 and a piping connector 91 disposed on the top surface 90 of the upper case 81. A communicating hole 92 disposed at the piping connector 91 communicates with the receptacle 88. Thus the inlet connecting portion 86 has the receptacle 88 and the piping connector 91, so as to function as a part to supply the fuel to the inlet 35 of the injector valve 25 by the communicating hole 92.

The housing 87, which is disposed at the position adjacent to the inlet connecting portion 86 of the upper case 81, has a hollow part opened at the bottom 85. An opening 93 for letting therethrough out the wiring connected to the terminal 38 at the side of the housing 87.

The lower case 82 is made of metal and a member for accommodating members of the outlet 36 of the injector valve 25 as shown in Figure 12 and Figure 14. In the lower case 82, the top surface 95 has a shape that is substantially in conformity with the bottom 85 of the upper case 81 and is opened. The lower case 82 is constituted mainly by a body receptacle portion 96 which is engaged with the shell 30 and the valve body housing 39 of the injector valve 25 and a protrusion part 97 for accommodating the terminal 38.

The body receptacle portion 96 disposed at the position which corresponds to the inlet connecting portion 51 of said case 47 is a hollow part

from the top 95 to the bottom 98 of the lower case 82. The top 95 of the receptacle portion 96 is substantially rectangular in a plan view, though the bottom 98 thereof has a shape that is substantially in conformity with the shell 30 and the valve body housing 39 of the injector valve 25. Further, at the bottom of the body receptacle portion 96, a receptacle 94 is formed for an end of the valve body housing 39 to be inserted therein. Thus, when inserting the injector valve 25 in the body receptacle portion 96, the body receptacle portion 96 is engaged with the shell 30 or the valve body housing 39, and an end of said housing 39 is inserted in the receptacle 94 as shown in Figure 15. Connecting portions 102 and 103 disposed at sides 100 and 101 of the lower case 82 respectively and also corresponding to downwardly of the body receptacle portion 96 communicates with the body receptacle portion 96. The connecting portion 102 is a part for connecting to the pump 15 and the connecting portion 103 is a part for flowing out the fuel jetted from the injector valve 25.

The protrusion part 97 is formed at the position adjacent to the body receptacle portion 96 of the lower case 82, and also opposite to the housing 87 when superposing the upper case 81. Since the top 95 of the protrusion part 97 is opened, the space for accommodating the terminal 38 of the injector valve 25 is formed between the housing 87 and the protrusion part 97 when the lower case 82 is covered with the upper case 81.

The upper case 81 is superposed so that the bottom 85 of the upper case 81 may cover the top 95 of the lower case 82 from above as shown in Figure 12, so as to form a housing 105 for accommodating the injector valve 25 and a terminal housing 106 for accommodating the terminal 38 which is protrusive from the shell 30 of the injector valve 25. The injector valve 25 is accommodated in the housing 105 so that the inlet 35 faces to the upper

case 81 and also the outlet 36 faces to the lower case 82. Further, the terminal 38 of the injector valve 25 is accommodated in the terminal housing 106. The wiring connected to the terminal 38 of the injector valve 25 is let out through the opening 93.

The inlet end of the injector valve 25 is inserted in the receptacle 88 of the upper case 81. The space between the injector valve 25 and the receptacle 88 is sealed by the O-ring 43 set in the groove 40 of the injector valve 25. In such a structure, it prevents the fuel from leaking from the gap between the injector valve 25 and the receptacle 88, and the vibration of the injector valve 25 hardly transmits to the upper case 81.

The outlet end 36 of the injector valve 25 is inserted in the body receptacle portion 96 of the lower case 82. The space between the injector valve 25 and the body receptacle portion 96 is sealed by the O-ring 45 set in the groove 41 formed at the outlet 36 of the injector valve 25. In such a structure, it makes possible to prevent the fuel from leaking from the space between the valve body housing 39 of the injector valve 25 and the body receptacle portion 96. Further, the O-ring 45 is made of rubber so as to have an elasticity. Therefore, it allows to absorb the vibration and the impact in the axial direction of the injector valve 25 generated by the reciprocation of the actuator 31. Besides, the O-ring 45 is made of a different material from the valve body housing 39 and the natural frequency of the vibration thereof are so different that the vibration generated in the valve body housing 39 is not amplified.

On the other hand, the valve body housing 39, around which the O-ring 45 is set, is the region that is not covered with the shell 30 and might result in easily leaking the vibration and the noise outside. Further, the valve body housing 39 is a part where the vibration and the noise are generated easily

resulting from the opening and closing of the valve since the valve body housing 39 installs the valve body 33 therein. However, in this preferred embodiment, the O-ring 45 is interposed between the injector valve 25 and the body receptacle portion 96, so that the vibration resulting from the operation of the injector valve 25 is absorbed in the O-ring 45 and hardly transmits to the upper case 81. Therefore, in the combustion apparatus 2 in this preferred embodiment, the metallic noise resulting from the operation of injector valve 25 hardly leaks outside.

In the combustion apparatus 1 in this preferred embodiment, the injector valve 25 is constituted in such a manner that the both ends thereof are supported by the upper case 81 and the lower case 82 via the O-rings 43 and 45. Therefore, it may prevent surely the vibration resulting from the operation of the injector valve 25 from transmitting, as well as minimize a horizontal vibration of the injector valve 25.

Further, a filling (not shown) made of silicone is filled in the space between the lower case 82 and the injector valve 25, and encloses the shell 30 and the valve body housing 39 of the injector valve 25. The filling made of silicone is an elastic material as well as the O-rings 43 and 45 so as to absorb the impact or the vibration. Still further, the filling is made of a different material from the valve body housing 39 and the natural frequency of the vibration thereof are so different that the vibration generated in the valve body housing 39 is not amplified. Consequently, most of the noise or the vibration resulting from the operation of the injector valve 25 is absorbed in the filling filled in the lower case 82, and is prevented from leaking outside.

The preferred embodiment illustrates the example of filling silicone resin in the lower case 82 as a filling, though it can dispense with the filling if the anticipated vibration of the injector valve 25 is comparatively minute.

Further, in the combustion apparatus 2 in the preferred embodiment, the vibration and the noise generated at the valve body housing 39 are so large that the structure to adopt the filling in respect to the lower case 82 is illustrated. However it is also possible to assume the structure to adopt the filling only in respect to the upper case 81 or in respect to both of the cases 81 and 82 in response to conditions such as the structure of the injector valve 25.

The preferred embodiment illustrates the example of adopting silicone resin in respect to the lower case 82, though the filling adopted in respect to the upper case 81 or the lower case 82 can be selected to one's discretion. More specifically, the filling adopted in respect to the upper case 81 or the lower case 82 can be any one such as a solid filling made by cutting and processing rubber, resin and the like, and a resinous filling such as a urethane filling, an epoxy filling and the like.

Still further, it can be constituted in such a manner to form a rectangular groove 83 at the bottom surface 85 of the upper case 81 and a rectangular protrusion 84 at the top surface 95 of the lower case 82 capable of engaging with the rectangular groove 83 as shown in Figures 16A and 16B. This arrangement prevents the relative displacement between the upper case 46 and the lower case 47 by the transmission of the vibration generated at the injector valve 25. Therefore, sealing condition of the housing 105 for accommodating the injector valve will not be deteriorated so as to minimize the leakage of the vibration and the noise of the valve resulting from the operation of combustion.

Such a structure in which the circular O-rings 43 and 45 are mounted around the injector valve 25 as the elastic member for buffering the vibration and the noise generated at the valve 25 is illustrated as an example in the

preferred embodiment, though this invention is not limited to that. More specifically, the elastic member mounted on the injector valve 25 can be a buffer 73 as shown in Figure 8. When connecting the injector valve 25 to the lower case 82 via the buffer 73, the main body 73a is interposed between the wall of the receptacle 94 disposed at the bottom of the body receptacle portion 96 and the valve body housing 39 of the injector valve 25 and also the flange 73b is interposed between the shell 30 and the bottom of the body receptacle portion 96 as shown in Figure 17.

When connecting the injector valve 25 to the lower case 82 via the buffer 73, the annular gap between the receptacle 94 and the valve body housing 39 of the injector valve 25 is fitted by the main body 73a, so that it may minimize the horizontal vibration of the injector valve 25, as well as it reduces further more the transmission of the vibration of the injector valve 25.

Further, the flange 73b of the buffer 73 fits in the annular gap formed between the injector valve 25 and the lower case 82 in the direction of the reciprocation of the actuator 31. Therefore, the flange 73b may absorb the vibration in the axial direction of the injector valve 25 resulting from the reciprocation of the actuator 31

In the present apparatus, the filling filled in the housing 70 is preferably made of a different material from the upper case and the lower case. In the preferred embodiment, the natural frequency of the silicone resin, the filling adopted in respect to the housing 70, is so different from the metal, forming the upper case and the lower case, that the vibration from the injector valve 25 is not amplified. Therefore, in this case it may hardly cause the transmission and the amplification of the vibration at the injector valve 25, and the noise generated resulting from the operation of the injector valve 25

hardly leaks.

The combustion apparatus 2 in the preferred embodiment can be of the type which an upper case (inlet joint) 115 and a lower case (outlet joint) 116, instead of the upper case 81 and the lower case 82 respectively, are connected to the injector valve 25 as shown in Figure 18. A structure of the upper case 115 and the lower case 116 is described below.

The upper case 115 wholly made of metal, is a member for accommodating a part of the inlet 35 side of the shell 30 of the injector valve 25 as shown in Figure 18 and Figure 19. The upper case 115, the bottom 117 of which is open, forms a valve housing 118 for accommodating most of the shell 30 of the injector valve 25. A receptacle 121, which is substantially the same diameter with the inlet end of the injector valve 25 is formed on an inner surface of a top plate of the valve housing 118.

Further a piping connector 91 is disposed on the top 120 of the upper case 115, similarly to the upper case 81. A communicating hole 92 formed at the piping connector 91 communicates with the receptacle 121.

On the other hand, the lower case 116 wholly made of metal is connected to the outlet 36 of the injector valve 25. The lower case 116 consists mainly of a valve connecting portion 122 connected to the injector valve 25 and a main body 123 connected to the fuel spraying nozzle 3 and the pump 15.

The valve connecting portion 122 comprises a flat portion 125, which shape is substantially in conformity with the bottom 115 of the upper case 117 and a receptacle 126, which is in conformity with the outlet end of the injector valve, and communicates with the main body 123 mentioned below. Further the main body comprises a connecting portion 127 for connecting to the pump 18 and a connecting portion 128 for flowing out the fuel jetted

from the injector valve 25.

The upper case 115 is superposed with the lower case 116 so that the bottom of the upper case 115 may cover the valve connecting portion 122 from above and secured to each other as shown in Figure 18, so as to form a housing 130 by the valve housing 118 of the upper case 115 and the flat portion 125 of the lower case 116. The injector valve 25 is accommodated in the housing 130 so that the inlet 35 faces to the upper case 115 and also the outlet 36 faces to the lower case 116.

A sound insulation wall 131 for enclosing the injector valve 25 is disposed in the housing 130. The sound insulation wall 131 is a cylindrical member made of rubber, and is in contact with the valve housing 118 of the upper case 115 that forms the housing 130 as shown in Figure 19. That is, the housing 130 is such a structure as having a double wall by the valve housing 118 and the sound insulation wall 131. After being attenuated greatly by the sound insulation wall 131, the vibration and the noise generated at the injector valve 25 are transmitted to the valve housing 118. Further, since the upper case 115 is made of metal while the sound insulation wall 131 is made of rubber, the natural frequency of both is so different that the vibration and the noise may not amplify. Therefore, the vibration and the noise are quite small, so that the noise resulting from the operation of the injector valve 25 is relatively small than the combustion noise resulting from the combustion operation to be hardly heard.

The inlet end and the outlet end of the injector valve 25 are inserted in the receptacle 121 of the upper case 115 and the receptacle 126 of the lower case 116, respectively. The space between the injector valve 25 and the receptacles 121 and 126 is sealed by the O-rings 43 and 45, for preventing the fuel from leaking from the space therebetween. Further, since both of

the O-rings 43 and 45 are made of rubber and elastic, the vibration generated in the injector valve 25 may be absorbed thereby. That is, the vibration generated in the radical direction of the injector valve 25 is absorbed by the O-ring 43 so as to prevent the horizontal vibration of the injector valve 25 on one hand. By using the O-ring 45 the force generated in the direction of the reciprocation of the injector valve 25 may be absorbed.

Still further, it is also possible to employ an inlet joint 132 having a structure as shown in Figure 20, instead of the inlet joint (upper case) 115. The inlet joint 132 is described below referring to the drawing. Only in this embodiment, the injector valve is arranged in the apparatus, the inlet 35 downwards and the outlet 36 upwards. The inlet joint 132 has the almost same structure as the inlet joint 115 so as to put the same reference numerals to the common parts and omit the description in details.

The inlet joint 132 made of metal as well as the inlet joint 115, comprises a main body 133, a nozzle holder 135 for the fuel spraying nozzle 3 and a branch 136 connected to the pump 15. The main body 133 is a main part of the inlet joint 132, the top 137 of which is open, and which has the almost same structure as the inlet joint 115. That is, the main body 133 has the valve housing 134 for accommodating the injector valve 25, in which housing 134 a receptacle 126 capable of engaging with the inlet end of the injector valve 25 is formed. Further, a filling made of silicone is filled in the space between the valve housing 134 and the injector valve 25.

The main body 133 comprises a nozzle connecting piping 138 that runs to the valve housing 134 therein and a nozzle holder 135 at the bottom 140 thereof. A nozzle attachment hole 141 for attaching the fuel spraying nozzle 3, which is formed at the nozzle holder 135, communicates with the nozzle connecting piping 138. Therefore, the remainder of the fuel flown

back un-sprayed from the fuel spraying nozzle 3 flows in the injector valve 25 mounted to the main body 133 through the nozzle connecting piping 138.

The branch 136, a portion branched from the main body 133, forms therein a pump connecting piping 142, where the fuel is capable of flowing and which communicates with the nozzle attachment hole 141 formed at the main body 133. That is, a piping is formed to connect the pump 18, a part of the feed canal 11, and the fuel spraying nozzle 12 by means of the branch 136.

The inlet joint 132 is connected and secured to the lower case 81 as well as the upper case 115. That is, the top 137 of the inlet joint 132 is superposed with the lower case 81 for facing to the bottom 140 thereof and secured to each other, so as to form the housing 130 enclosed with the valve housing 134 of the upper case 115 and the flat portion 125 of the lower case 81. Since the injector valve 25 is enclosed with the housing 130, the noise resulting from the operation of the injector valve 25 is attenuated in the wall forming the housing 130 and hardly leaks outside. Further, the filling is filled in the housing 130 of the inlet joint 132 so as to absorb in the filling most the noise or the vibration at the injector valve 25. Thus, by connecting the injector valve 25 by using the inlet joint 132 and the lower case 81, the noise and the vibration at the injector valve 25 can be minimized.

Still further, the inlet joint 132 comprises a nozzle holder 135 and a branch 136 in addition to the main body 133. A nozzle connecting piping 138 for connecting the valve 25 and the nozzle 12 and a pump connecting piping 142 for connecting the nozzle 12 and the pump 15 are united in one piece by the upper case. Therefore, by using the inlet joint 132, it is possible to simplify the canal for supplying the fuel to the fuel spraying nozzle 3, and to assemble readily the combustion apparatus 2. Further,

employing the inlet joint 132 may make it possible to decrease numbers of parts of the combustion apparatus 2, as well as reduce the manufacturing cost.

Though in the embodiments described above, any of the O-rings 43, 45, 75 and the buffer 73 are made of rubber, they can be made of any material if it is the one being elastic. More specifically, the O-rings 43, 45, 75 and the buffer 73 can be made of any material such as natural rubber, acrylonitrile-butadiene rubber (NBR), fluoroelastomer, styrene butadiene rubber (SBR), polybutadiene rubber (BR), polyisoprene rubber (IR), special purpose rubbers, chloroprene rubber (CR), isobutylene-isoprene rubber (IIR), ethylene propylene rubber (EPDM), epichlorohydrin rubber (CHR), chlorosulphonated polyethylene (CSM), acrylic rubber (ACM), silicone rubber, urethane rubber. Especially, fluorosilicone rubber brings an excellent effect for the vibration-isolating and the sound insulation.

The combustion apparatus provided in each of the embodiments described above is not intended to limit the scope of the present invention but does merely exemplify a lot of feasible modes and embodiments thereof.